

TERTIARY COLEOPTERA FOSSILS FROM THE
NORTH AMERICAN ARCTIC

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ABSTRACT

Studies of fossil Pleistocene beetles in the Arctic indicate little evolution or extinction during the last million years. A few Arctic localities have yielded fine Tertiary beetle fossils, of late Miocene age. These older materials are of great evolutionary significance, as many apparently extinct species are included. Proper analyses of the fossil forms depend on an understanding of relationships among extant forms. Taxonomic revisions are therefore at their most useful when phylogenetic constructs have been included, ready for testing and refinement.

INTRODUCTION

Most coleopterists are well aware of the burgeoning role of Coleoptera fossils in Pleistocene paleoecological studies (Coope 1970, 1975). In those areas of the world where the existing coleopterous fauna is well documented, beetle fossils may be more sensitive indices of climatic change than even such traditional types of evidence as fossil pollen or plant macrofossils (Coope and Brophy 1972; Osborne 1974; Coope 1975). Although fossils of Pleistocene beetles have been of interest to various workers for many years, it is only in the last 30 years that their value for paleoenvironmental studies has been realized. The centre of such research has been England, where since the late 1950's G. R. Coope and his associates have carried out numerous detailed studies. More recently, similar investigations have been initiated in other parts of Europe (Panfilov 1965; Ullrich 1972; Kopenen and Nuorteva 1973; Angus 1975) and Siberia (Kiselev 1973; Matthews 1974a). North American paleoecological studies using fossil Coleoptera have lagged behind those of western Europe, but several recent papers (Coope 1968; Matthews 1968, 1974b, 1975; Ashworth 1975; Ashworth and Brophy 1972; Ashworth *et al.* 1972; Morgan 1972, 1975) show that the approach is quickly gaining acceptance on this continent.

An outstanding finding common to all of these studies is that the evolution of the Coleoptera has been very slow. The majority of fossils that preserve definitive structural characters can be matched with comparable elements of extant species, this being so even for fossils as old as the early Pleistocene (Matthews 1974b). Occasionally, well preserved Pleistocene fossils seem to have no living counterpart, suggesting that they refer to extinct species; however, these have usually proved, on further study, to be contemporary residents of sites far removed from the fossil locality (Coope 1974; Ullrich and Coope 1974) or, as in the case of the weevil *Vitavitus thulius* (Kissinger 1973), undescribed members of the existing local fauna (Matthews 1974b). Thus for those taxa that are represented by fossils, there seems to have been little evolution or extinction for approximately the

last one million years. If fossils of extinct species with a bearing on evolutionary history are to be found, they will likely occur in Tertiary rather than Pleistocene sediments.

Unfortunately many Tertiary beetle fossils are preserved as casts or impressions that even under the best conditions are usually inadequate for more than tentative assessment of generic and specific affinities (e.g., see figures in Gersdorf 1969, 1971; Larsson 1975; Smiley *et al.* 1975). Recently, however, well preserved Tertiary fossils have been discovered at sites in western Alaska and the Canadian Arctic (Hopkins *et al.* 1971; Matthews 1974c, 1976a). Like the Coleoptera fossils of Pleistocene age, these Tertiary fossils consist primarily of disarticulated fragments (heads, pronota, elytra, etc.), which may be readily compared with corresponding parts of recent beetle specimens.

Since many of these newly discovered Tertiary beetles seem to represent extinct species, they have much more evolutionary significance than do the Pleistocene fossils. One purpose of this report is to make coleopterists aware of the information at hand, most of which has been discussed previously only in non-entomological journals. In addition, this paper also registers a plea for coleopterists to recognize the special problems associated with study of such fossils and to be aware of the information which they, as taxonomists, possess that might greatly aid in the interpretation of the fossils.

FOSSIL LOCALITIES AND AGE

Table 1 is a list of the Tertiary fossils discovered as of March, 1976. Although the list includes only Coleoptera, the fossil assemblages also contain fragments of Diptera, Hymenoptera (especially Ichneumonoidea and Formicidae), Homoptera (Cicadellidae), oribatid mites, and fragments of Crustacea (Notostraca and Cladocera).

All of the fossils listed in the table come from 3 localities, 1 being the Lava Camp site in western Alaska (Hopkins *et al.* 1971) and the other 2 (Meighen Island and Banks Island—see Table 1) representing widely separated exposures of the Beaufort Formation in the Canadian Arctic Archipelago (Fig. 1) (Matthews 1974c, 1976a). Specifically, Banks Island fossils originate in autochthonous and detrital peats within the upper member of the Beaufort Formation at Ballast Brook on the northwestern side of the island. The Meighen Island specimens were found in peats at several stratigraphic levels in Beaufort Formation exposures on the west side of the island. The best preserved Coleoptera fossils discovered to date come from Meighen Island; however those from Lava Camp are perhaps more significant because their age is better known.

The reason for this is that all of the fossils from Lava Camp were contained in organic sediments immediately underlying a dated basalt. Wood and peat within these sandy sediments are charred, indicating that they (and the insects associated with them) represent a forest environment of about the same age as the time of the extrusion of the lava flow, which is known from Potassium Argon analyses to have occurred approximately 5.7 million years ago (Hopkins *et al.* 1971). Originally the Lava Camp site was assigned to the Pliocene, but now that the beginning of the Pliocene is placed at 5 million years, Lava Camp beetle fossils must be referred to the late Miocene.

The age of the Beaufort Formation fossils is less certainly known. Comparison of fossil plant assemblages from Beaufort sites with those described in southern Alaska (Wolfe *et al.* 1966) suggests that all Beaufort sediments seen to date are at least of Miocene age (Hills *et al.* 1974; Hills and Bustin 1976). Many of the plant and insect fossils are undoubtedly older, possibly greater than 8 million years (Matthews 1976a)—that being the age of the boundary of the Homerian and Clamgulchian time stratigraphic units as defined in Alaska (Wolfe *et al.* 1966; Triplehorn *et al.* 1977).



Fig. 1: Sites mentioned in the text. Stippled area of the Arctic Archipelago is the approximate extent of the Beaufort Formation.

FOSSIL PRESERVATION

Despite their great age, the fossils listed in Table 1 are exceptionally well preserved (Fig. 2). A few are partially articulated and contain fragments of wings and genitalia. The majority, however, represent fragments of beetles, mostly pronota, heads, and elytra. The fragments are neither severely crushed nor distorted and display no visible evidence of chemical alteration. Though not as well preserved as amber specimens (Bachofen-Echt 1974), they are more numerous and represent a wide range of biotopes. Many of them possess remnants of the original vestiture, punctation, microsculpture, and colour. One constant difference between the fossils and modern specimens is that the former are always darker (Kiselev 1973),

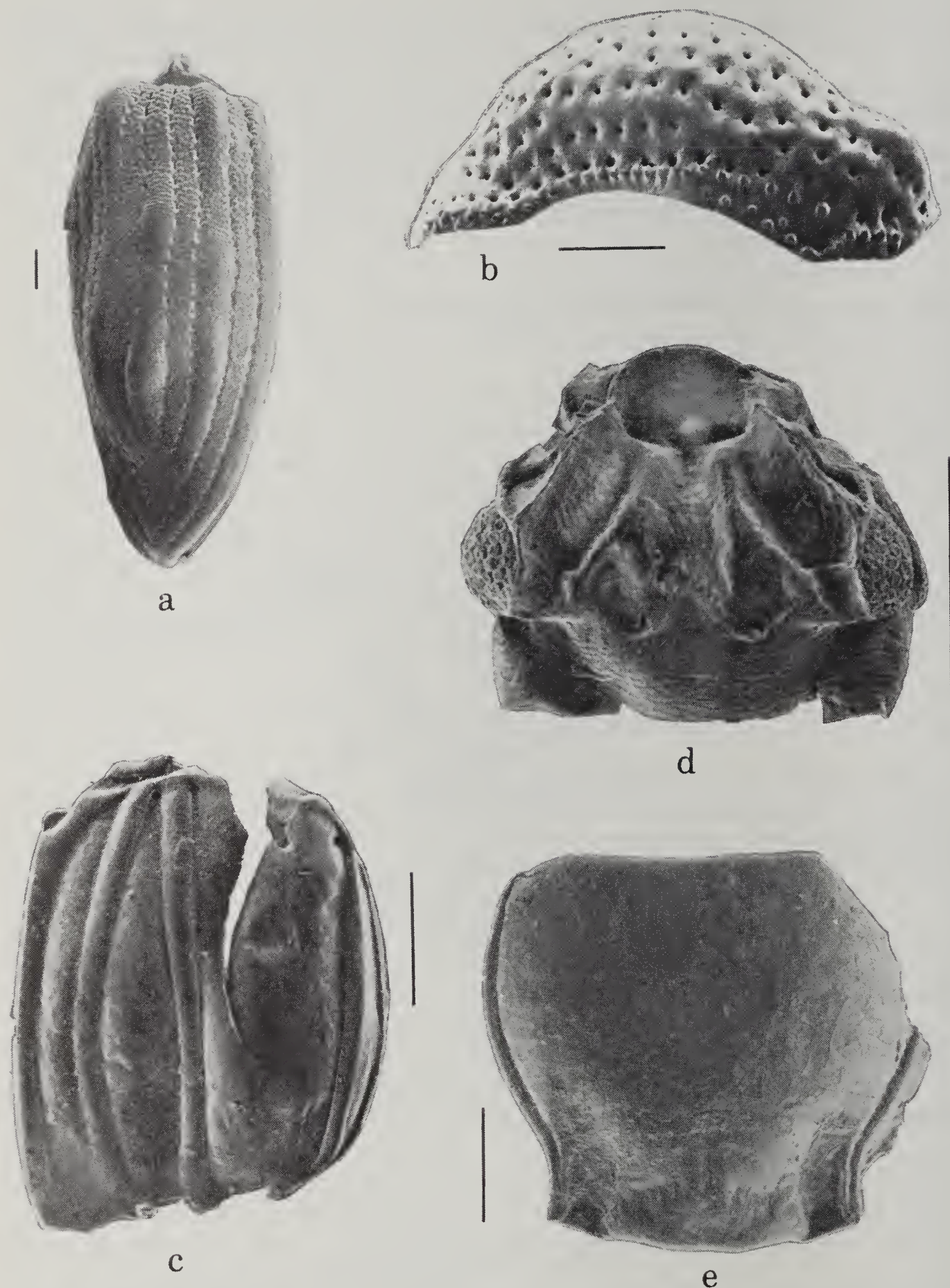


Fig. 2: a) *Grypidius* cf. *G. equiseti* Fab. (Curculionidae); 1ft. elytron; GSC-48727; Meighen Island, sample JVM 5-73; b) *Georyssus* sp. (Georyssidae); lateral view of rt. elytron; Lava Camp, Alaska; same specimen illustrated by line drawing in Fig. 7a of Hopkins *et al.* 1971; c) *Kalissus* cf. *K. nitidus* Lec. (Staphylinidae: Micropeplinae); rt. elytron; Lava Camp, Alaska; same specimen identified as *Kalissus nitidus* and illustrated in Fig. 2 of Hopkins *et al.* 1971; d) *Micropeplus sculptus* Lec. (Staphylinidae: Micropeplinae); head (slightly distorted); GSC-48728; Banks Island, sample JVM 3-73; e) *Bembidion* (*Trepanedoris*) cf. *B. psuedocautum* Lth. (Carabidae); pronotum; Kugruk River, Alaska, Loc. 1226, near Lava Camp. Scale bar = 0.25 mm.

which means that the colour pattern of species with maculate elytra is usually somewhat obscured. A few of the carabid fossils also possess anomalous punctures on the elytra or pronota, but these features are clearly post-mortual in origin and have been observed as well on Pleistocene specimens (Lindroth 1948). Figure 2 is intended to show the excellent preservation of the fossils by illustrating specimens from several different families.

IDENTIFICATION NOTES

Several features of Table 1 require explanation. Note for example the uneven precision of identifications. Some fossils are identified only to the familial level; many are referred to genera; while a considerable number of the carabid specimens and a few in other families are compared with ("cf") existing species. In large measure this variation of resolution is related to the lack of diagnostic features on some fossils (despite their excellent preservation) and to the fact that a number of the fossils refer to groups which are today poorly known taxonomically. As an example of the first situation note that two important Coleoptera groups, Cerambycidae and Cicindelidae, are identified only to familial level, the reason being that mandibles of adults were the only fossils available. On the other hand well preserved, diagnostic specimens relating to the Omaline staphylinids, Ptiliidae, Byrrhidae, Colydiidae (*Namunaria*) are available, but cannot be compared with existing species because portions of those groups require taxonomic revision.

In contrast, the Carabid fauna of Canada and Alaska is well documented. Accordingly not only is it possible to relate carabid fossils to existing genera (all of them occurring in Alaska and Canada today) but in a number of instances the extant species which the fossils most resemble are also named. The similarity of fossils to modern specimens is remarkable (cf. *Diacheila* fossil in Matthews 1976a); nevertheless preliminary studies indicate that most of them will ultimately be found to refer to undescribed, extinct species. A few have already been described and treated as such (Matthews 1970, 1976b) while others are currently under study. It is worth noting, however, that the age of these late Tertiary assemblages is not beyond the range of all existing species since both the Lava Camp and Meighen Island assemblages also contain fossils of species (e.g., *Micropeplus tessera*) which are extant.

DISCUSSION

Current research on Tertiary Coleoptera fossils from northern North America is centered on several exposures of the Beaufort Formation, particularly the ones on Meighen Island in the Canadian High Arctic. But samples from the Alaskan Lava Camp site are still under study; a site near Lava Camp has yielded a small assemblage of Tertiary fossils (see Fig. 2e and Matthews 1977); and there is hope that sediments beneath a 5 million year old volcanic ash in interior Alaska will also yield well preserved beetle fragments. Such fossils are important for evolutionary studies, but they may serve another purpose—correlation and dating, a use to which fossil insects have seldom been put (Matthews 1976b).

Table 1. Fossil Coleoptera from late Tertiary Sites in Arctic North America.

TAXON	Lava Camp	Meighen Island	Banks Island
CICINDELLIDAE			
Genus?		x	
CARABIDAE			
<i>Trachypachus</i> cf. <i>T. holmbergi</i> Mann.		x	
<i>Trachypachus</i> sp. A.	x	x	
<i>Trachypachus</i> sp.			x
<i>Carabus</i> cf. <i>C. truncaticollis</i> Eschz.	x		
<i>C.</i> cf. <i>C. vietinghoffi</i> Adams		x	
<i>C.</i> cf. <i>C. chamissonis</i> Fisch.		x	
<i>Carabus</i> sp. A.		x	
<i>Leistus</i> sp.	x		
<i>Pelophila</i> cf. <i>P. borealis</i> Payk.		x	
<i>Nebria</i> cf. <i>N. nivalis</i> Sahlb. ¹	x		
<i>Nebria</i> cf. <i>gyllenhali</i> sp. grp.		x	
<i>Opisthius</i> cf. <i>O. richardsoni</i> Kirby		x	
<i>Notiophilus</i> cf. <i>N. aeneus</i> Herbst	x		x?
<i>N.</i> cf. <i>N. directus</i> Casey		x	
<i>Notiophilus</i> sp.			x
<i>Diacheila</i> cf. <i>D. polita</i> Fald.		x	
cf. <i>Diacheila</i>			x
<i>Blethisa</i> cf. <i>B. multipunctata</i> L.		x	
<i>B.</i> cf. <i>B. catenaria</i> Brown		x	
<i>Elaphrus</i> cf. <i>E. lapponicus</i> Gyll.		x	
<i>E.</i> cf. <i>E. clairvillei</i> Kirby ²		x	
<i>E. riparius</i> complex ²		x	
<i>Elaphrus americanus</i> complex ²		x	
<i>Elaphrus</i> sp.			x
<i>Dyschirius</i> cf. <i>D. laevifasciatus</i> Horn		x	x
<i>D.</i> (<i>Dyschiridius</i>) sp.	x		
<i>D.</i> cf. <i>D. globulosus</i> say	x	x	
<i>Patrobus</i> cf. <i>P. septentrionis</i> Dej.	x	x	
<i>Patrobus</i> sp.			x
<i>Platidiolus</i> cf. <i>P. vandykei</i> Kurn.		x	
<i>Trechus</i> sp.	x		
<i>Asaphidion alaskanum</i> Wick		x	x
<i>Bembidion</i> cf. <i>B. lapponicum</i> Zett.		x	
<i>B.</i> (<i>Chrysobracteon</i>) sp.			x?
<i>B.</i> cf. <i>B. nitidum</i> Kirby			x
<i>B.</i> cf. <i>B. dyschirinum</i> Lec.		x	
<i>B.</i> (<i>Plataphodes</i>) spp.	x	x	x
<i>B.</i> cf. <i>B. planatum</i> Lec.		x	
<i>B.</i> cf. <i>B. bimaculatum</i> Kirby		x	
<i>B.</i> cf. <i>B. nigripes</i> Kirby		x	
<i>B.</i> cf. <i>B. acutifrons</i>	x		

Table 1 (Cont.).

<i>B. cf. fortistriatum</i> Motsch.		x	
<i>B. (Trepanedoris)</i> sp.	x		
<i>Bembidion</i> spp.	x	x	x
<i>Tachyta</i> cf. <i>T. angulata</i> Casey ³			x
<i>Pterostichus</i> cf. <i>P. corvinus</i> Dej.	x		
<i>P. cf. P. circulosus</i> Lth.		x	
<i>P. (Derus)</i> sp.		x?	
<i>P. (Cryobius)</i> cf. <i>P. kotzebuei</i> Ball		x	
<i>P. (Cryobius)</i> cf. <i>P. tareumiut</i> Ball		x	
<i>P. (Cryobius) ventricosus</i> sp. grp.		x	
<i>P. (Cryobius) brevicornis</i> sp. grp.		x	
<i>P. (Cryobius)</i> cf. <i>P. nivalis</i> Sahlb.	x		
<i>P. (Cryobius)</i> spp.	x?	x	x?
<i>P. cf. P. vermiculosus</i> Men.	x	x	
<i>P. cf. P. haematopus</i> Dej.		x	
<i>Agonum</i> cf. <i>A. consimile</i> Gyll.		x	
<i>A. cf. A. bicolor</i> Dej.		x	
<i>A. cf. A. cincticolle</i> Say		x	
<i>Agonum</i> sp.	x		x
<i>Amara</i> cf. <i>A. alpina</i> Payk.		x	
<i>A. cf. A. carinata</i> Lec.		x	
<i>Amara</i> sp.	x		
<i>Harpalus</i> cf. <i>H. amputatus</i> Say		x	
<i>H. cf. H. cordifer</i> Notman		x	
<i>Dromius</i> cf. <i>D. ruficollis</i> Motsch.	x		
<i>D. cf. D. piceus</i> Dej.		x	
<i>Chlaenius</i> sp.		x	
DYTISCIDAE			
<i>Hydroporus</i> sp.		x	
<i>Agabus</i> sp.		x	
<i>Ilybius</i> sp.		x	
<i>Colymbetes</i> sp.		x	
GYRINIDAE			
<i>Gyrinus</i> sp.		x	x
HYDROPHILIDAE			
<i>Helophorus</i> sp.		x	
<i>H. (Cyphelophorus) coopei</i> Matth.*	x		
<i>H. (Cyphelophorus) meighenensis</i> Matth.*		x	
<i>Hydrobius</i> sp.		x	
GEORYSSIDAE			
<i>Georyssus</i> sp.	x	x	
STAPHYLINIDAE			
<i>Kalissus</i> cf. <i>K. nitidus</i> Lec.	x		
<i>Kalissus</i> sp. A.		x	
<i>Micropeplus tesserula</i> Curtis	x		
<i>M. hopkinsi</i> Matth.*	x		
<i>M. hoogendorni</i> Matth.*	x		
<i>M. sculptus</i> Lec.		x	x
<i>Carpelimus</i> sp. ¹		x	

Table 1 (Cont.).

<i>Bledius</i> sp.			X	
<i>Syntomium</i> sp.	X			
<i>Arpedium</i> sp.	x?		X	
<i>Acidota</i> sp.			X	
<i>Pycnoglypta</i> cf. <i>P. lurida</i> Gyll.			X	
<i>Olophrum</i> sp.			X	
<i>Omalium</i> sp.			X	
<i>Micralymma</i> cf. <i>M. brevilingue</i> Schiødt			X	
Genus (Coryphiini?)	X			
<i>Stenus</i> spp.	X		X	X
<i>Quedium</i> (<i>Raphirus</i>) <i>aenescens</i> sp. grp.			X	
<i>Tachinus</i> cf. <i>T. jacuticus</i> Popp.			X	
<i>Tachinus</i> sp.				X
<i>Tachyporus</i> sp.			X	
<i>Gymnusa</i> sp.			X	X
<i>Lathrobium</i> sp.	X			
PSELAPHIDAE				
Genus?				X
SILPHIDAE				
<i>Silpha</i> cf. <i>S. ramosa</i> Say			X	
<i>Phosphuga</i> cf. <i>P. atrata</i> L.			X	
LEPTODIRIDAE				
<i>Colon</i> sp.				x?
LEIODIDAE				
Genus?	X		X	
PTILIIDAE				
<i>Acrotrichis</i> sp.	X			
<i>Micridium</i> sp. ⁵	X			
SCYDMAENIDAE				
Genus?	X		X	
HISTERIDAE				
<i>Platysoma</i> (<i>Cylister</i>) sp. ⁶			X	
SCARABAEIDAE				
<i>Aegialia</i> sp.			X	
BYRRHIDAE				
<i>Simplocaria</i> sp.	X		X	
<i>Byrrhus</i> sp.	X		X	
<i>Cytilus</i> sp.			X	
<i>Morychus</i> sp.			X	
<i>Curimopsis</i> sp.			X	
<i>Eusomalia</i> ?				X
ELATERIDAE				
<i>Hypolithus</i> cf. <i>H. sandborni</i> (Horn) ⁷			X	
ANOBIIDAE				
Genus	X			
TENEBRIONIDAE				
<i>Iphthimus</i> ?	X			
ANTHICIDAE				
Genus?	X		X	

Table 1 (Cont.).

COCCINELLIDAE			
Genus?		x	
LATHRIDIIDAE			
<i>Enicmus</i> sp.	x		
<i>Stephostethus</i> sp.		x	
Genus?	x	x	x
COLYDIIDAE			
<i>Namunaria</i> sp.	x		
<i>Bitoma</i> sp.		x?	
CERAMBYCIDAE			
Genus?	x		
CHRYSOMELIDAE			
<i>Donacia</i> sp.		x	
<i>Chrysolina</i> sp.	x		
CURCULIONIDAE			
<i>Apion</i> sp.		x	
<i>Vitavitus thulius</i> Kissinger ⁴	x		
<i>Vitavitus</i> cf. <i>V. thulius</i> Kissinger		x	
cf. <i>Lepidophorus</i>	x		
<i>Lepyryus</i> sp.		x	
<i>Grypidius</i> cf. <i>G. eguiseti</i> Fab.		x	
<i>Notaris</i> sp.		x	
<i>Lixellus</i> sp.			x?
<i>Cleonus</i> sp.			x
<i>Ceutorhynchus</i> sp.	x	x	

¹Identified by D. H. Kavanaugh, California Academy of Science.²Identified by H. Goulet, University of Alberta.³Identified by T. L. Erwin, U.S. National Museum of Natural History, Washington, D.C.⁴Identified by J. M. Campbell, Biosystematics Institute, Ottawa.⁵Identified by H. S. Dybas, Field Museum of Natural History, Chicago.⁶Identified by R. L. Wenzel, Field Museum of Natural History, Chicago.⁷Identified by E. C. Becker, Biosystematics Institute, Ottawa.⁸Identified by D. G. Kissinger, Loma Linda University, California.

*Extinct?

These late Tertiary beetle fossils also reveal some interesting distributional facts. For example it was a surprise to discover fossils similar to, if not conspecific with, the eastern north American ground beetle *Notiophilous aeneus* in the Lava Camp assemblage from western Alaska. Similarly *Dromius ruficollis* and *Phosphuga atrata*, 2 species to which several of the fossils are compared, are presently Palearctic in distribution, and the histerid *Platysoma* fossil is most similar to species which presently occur in Europe and Siberia (R. L. Wenzel, pers. comm., 1976).

The closest relatives to many of the Meighen Island beetle species live today near the forest-tundra boundary (Hudsonian zone); similar environmental conditions are implied by the plant fossils (Hills and Matthews 1974; Matthews 1976a). In spite of this fact, some of the taxa listed for

Meighen Island (e.g., *Chlaenius*, *Georyssus*, the *laevifasciatus* group of *Dyschirius*) are not represented in the forest-tundra ecotone fauna of today, suggesting that the late Miocene Hudsonian fauna was more diverse than at present. Equally as intriguing as the fact that Meighen Island was near the forest limit in late Miocene time, is the implication from paleomagnetic studies (Symons 1969) that the Island was then, as now, within a high latitude region. This fact shows how different the late Miocene climate of the far north must have been from that of the present or even the warmer intervals of the Pleistocene.

Such findings are basically of a paleoecological sort, and though interesting are not the most significant from an entomological standpoint. For the entomologist the greatest promise of the fossils is what evolutionary information they will reveal. However, before some of the specimens can be examined in this light, more must be known about the present Hudsonian fauna. One of the purposes of this paper is to show, by listing fossils that have been found and illustrating their state of preservation, that entomologists can contribute significantly to study of the fossils if, in their taxonomic revisions, they attempt to analyze or at least discuss characters that are likely to be preserved on the fossils. Entomologists can contribute to the study of the fossils in another fundamental way, by simply including in their taxonomic analyses comments on evolutionary implications. Since the fossils discussed here are so obviously related to existing taxa, part of the paleontologist's job entails study of these extant species for the purpose of discovering characters of potential evolutionary significance. The task is simplified and the data more reliable if such conclusions form part of the original taxonomic treatment of a group. The ideal situation is a revision which includes a detailed phylogenetic construct (e.g., Whitehead 1972; Ball 1975), ready for testing and refinement by study of the relevant fossils.

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